

Southeast Asian Fisheries Development Center

Aquaculture Department

SEAFDEC/AQD Institutional Repository

<http://repository.seafdec.org.ph>

Journals/Magazines

Aqua Farm News

1995

Aqua Farm News Volume 13(02) March - April 1995

Aquaculture Department, Southeast Asian Fisheries Development Center

<http://hdl.handle.net/10862/2467>

Downloaded from <http://repository.seafdec.org.ph>, SEAFDEC/AQD's Institutional Repository



AQUA FARM NEWS



ISSN 0116-6573

A publication of SEAFDEC Aquaculture Department, Iloilo, Philippines

Vol. XIII No. 2

March-April 1995

AQUACULTURE WASTES

A threat to the environment

Aquaculture activities, like other livestock culture, generate substantial amounts of nutrients (nitrogen and phosphorus) which exert a biochemical oxygen demand (BOD) on the receiving waters. The large amounts of organic and inorganic substances such as food wastes and fish feces discharged from intensive aquaculture farms continually accumulate and contaminate the marine environment.

The rapid development of the marine fish culture industry in every part of the world has contributed to the deterioration of our environment. Chemical analysis of the bottom sediments from 24 fish culture zones in Hong Kong's coastal waters showed serious organic and nutrient enrichment. Water quality within 55 fish cul-

ture zones in Port Shelter was also poorer than the ambient water quality. This is indicated by lower oxygen and high ammonia and nitrogen levels. This signals imminent water pollution problems (CY Lam 1990).

Ecologists believe that countries actively engaged in mariculture activities face pollution problems. However, negative environment impacts may be minimized by a combined input and output control on the nutrients, organic matter and water use.

Control measures to reduce pollution effects should therefore be done. This issue covers how aquaculture systems could threaten the marine environment. It also features effective management of aquaculture operations.

Catherine Lam of Environmental Protection Department in Hongkong recommends: improvement of fish husbandry methods, siting of fish culture zones in more open waters, fish farming by rotation, and the introduction of alternative culture methods.

Ecological impacts of coastal aquaculture developments

The type and scale of any ecological change associated with coastal aquaculture development will depend on the method of aquaculture, the level of production, and the biological, chemical and physical characteristics of the coastal area. The following are general discussions of these impacts:

Enrichment

The release of soluble inorganic nutrients (nitrogen and phosphorus) from intensive fish and shrimp farming has the potential to cause nutrient enrichment and eutrophication (increase in primary production) of a water body. It has also been suggested that the release of dissolved organic compounds together with other components of the diet such as vitamins could influence the growth or toxicity of particular species of phytoplankton. There are examples of eutrophication of lacustrine waters as a result of fish farming, but few examples from coastal waters. At the present level of coastal fish farming, nutrient enrichment and eutrophication of open coastal water is unlikely, but could occur in semi-enclosed coastal embayments (fjords, inlets and lagoons) which have restricted exchange of water with more open coastal waters. One example of an increase in phytoplankton biomass attributed to nutrient enrichment by fish farming is from a sheltered archipelago in Finland. Increasing eutrophication can lead to ecologically undesirable consequences and there is the possibility that waste released from fish farms could stimulate the growth of species harmful to farm stock. During the last decade, there have been many instances of mass mortality of farmed fish caused by the occurrence of harmful algae. There is, however, no evidence that the occurrence of these harmful events was due to the release of waste-compounds from the fish farms.

The increase in dissolved nutrients can be estimated using a simple mass balance approach and relating the output of nutrients to the volume and flushing time (dilution rate) of the water body. This is, however, regarded as only an approximate. It is assumed to be a complete dispersal but actually about 50% of the water is changed.

The small sea-loch left during ebb tide goes back with the flood.

The deposition of organic fish farm and bivalve waste has been shown to cause enrichment of the benthic ecosystem in the vicinity of the aquaculture operation. The changes which take place include: the formation of anoxic sediments with, in extreme cases, the release of carbon dioxide, methane and hydrogen sulphide; increased oxygen consumption by the sediment and efflux of dissolved nutrients; and changes in the community structure of the benthic macrofauna. With respect to changes in the macrofauna, the effects range from a reduction in diversity and increase in opportunistic and pollution-tolerant species to the complete absence of macrofauna. The release of hydrogen sulphide gas, with hydrogen sulphide dissolved in the water deteriorated the health of farmed fish. A high level of enrichment leading to souring of sites has been reported from a number of fish farms in several countries. It has been estimated that 30% of oyster and mussel farms in France are periodically abandoned or relocated because of the accumulation of biodeposits. These are clear examples of how production can exceed the capacity of the site to assimilate the amount of waste generated and how ecological change can limit the long-term viability of a site.

Interaction with the food web

The large scale, extensive cultivation of bivalves can interact with the marine food web in two ways. Firstly, by the removal of phytoplankton and organic detritus and, secondly, by competing with other planktonic herbivores.

It is possible that the siting of bivalve farms in coastal embayments could reduce the natural productivity of the embayment. Bivalve grown by suspended culture methods will compete with other planktonic herbivores.

The carrying capacity of a natural ecosystem is the maximum production of a species which can be maintained by naturally available food resources. This particularly applies to the production of bivalves. Carrying capacity can be assessed by evaluating historical records of bi-

valve culture, measuring the availability of phytoplankton biomass or undertaking more sophisticated studies of carbon flux through the food web. Furthermore, models have been formulated to predict the carrying capacity of some coastal areas, the general principles of which hold true for any coastal area.

Oxygen consumption

Aquaculture production can be limited by the availability of oxygen. An assessment of this limit for an embayment can be obtained by establishing a mass balance. That is comparing the oxygen demand of the stock to the pool of available oxygen and the rate of supply. With respect to oxygen, there have been some attempts to model the production potential in relation to aquaculture development.

In addition to the oxygen demand by the culture species, wastes and biodeposits released by a farm have a high biochemical oxygen demand. Deposition of organic waste increases the consumption of oxygen by the sediment and can result in oxygen depletion of the bottom water. A reduction in the concentration of dissolved oxygen in water passing through cage farms has also been reported.

In low energy coastal environments such as the deep basins of some fjords and inlets, the retention of deep water within the basin for a period of time results in a natural depletion of oxygen. The deposition of wastes would increase the oxygen deficit. This potential problem has been recognized in several countries. In Norway, only a low level of aquaculture production is allowed in fjord with deep isolated basins and this is restricted to the shallow, relatively well flushed nearshore areas.

Disturbance of wildlife and habitat destruction

All forms of aquaculture have the potential to affect wildlife. Human activity can be disruptive in the vicinity of important breeding colonies and feeding grounds, while the aquaculture facility itself can attract predatory species. In Germany, cormorant populations have increased as a result of poor farming. However, there have been few detailed studies on the ecological effects of aquaculture operations on wildlife.

There are reports on the impact of some forms of aquaculture on wildlife habitat. In the

Philippines, 200,000 hectares of mangrove have been destroyed and in Thailand an estimated 25% of the mangrove resource has been lost as a result of aquaculture development.

Coastal wetlands are among the most productive ecosystems and are important in sustaining the ecological integrity and productivity of adjacent coastal waters. Mangrove areas are important nursery grounds for many commercial fish and shrimp species.

Interaction between escaped farmed stock and wild species

The rapid development of marine cage farming of salmonids in Europe has raised concerns about the impact of escaped fish on natural populations. It has been suggested that farmed fish have been selected for traits which make them suitable for farming but less well adapted to the natural ecosystem. Thus, escaped fish could not initially compete with native stocks, but then decline, or the progeny resulting from interbreeding could be poorly adapted to the ecosystem.

There is insufficient information available to judge whether this interaction has a serious ecological impact. It is known that farmed fish do escape and that the numbers of escapees can be of large quantities. Some countries have initiated studies to address this issue and in recognition of the potential problem, Norway prohibits the siting of salmon farms within 30 km of important salmon rivers.

Introduction and transfers

A number of fish, invertebrate and seaweed species, have been transferred or introduced from one region to another for aquaculture purposes. A distinction has been made between the two kinds of movements which differ in their purpose and potential effect.

Transfer take place within the present geographical range of a species and are intended to support stressed populations, enhance genetic characteristics or re-establish a species and are intended to insert totally new taxa into the flora and fauna.

The problems associated with transfers and introductions have been well studied and recorded. Transfers and introductions may alter or impoverish the biodiversity of the receiving eco-

next page

system through interbreeding, creation, competition for food and space, and habitat destruction.

Examples of the type of disease problem which have arisen in the past from such movement are illustrated by the transfer of salmon smolts from Sweden to Norway and Finland, the introduction of infected ova of coho salmon (*Oncorhynchus kisutch*) from the USA and the introduction of Japanese oysters (*Crassostrea gigas*) to France .

Bioactive compounds (including pesticides and antibiotics)

Bioactive compounds should be considered as part of overall disease control strategies. However, it is accepted that many bioactive compounds, including pesticides and antibiotics, are used extensively in coastal aquaculture as the sole means of disease or pest control. Indeed, the success or failure of aquaculture may in certain circumstances depend on the timely use of such bioactive compounds to combat infectious diseases and parasites. In general, the use of such compounds in aquaculture is haphazard, often reflecting the whims of the aquaculturists or disease adviser.

Longevity of inhibitory compounds in animal tissues

There is an increasing literature indicating that bioactive compounds linger in animal tissues for greater periods than had been recognized. It was reported that the antibiotic trimethoprim remained in rainbow trout muscle for 77 days after the cessation of treatment. It is recommended that for rainbow trout maintained at a water temperature of 10°C, a withdrawal period of 60 days is necessary when using antibiotics such as oxytetracycline and potentiated sulphonamides. This period is much longer than normally practiced in aquaculture.

Discharge of inhibitory compounds in the aquatic environment

The widespread use of inhibitory compounds in aquaculture has caused fears of the potential release of the bioactive component into the aquatic environment. In the case of antibiotics, this could damage biological filters in recirculating systems. Recent published data suggest that only 20-30% of antibiotics are actually taken up by fish from medicated food; thus, approximately

70-80% reaches the environment, notably from uneaten medicated food. With oxytetracycline in seawater, it has been established that degradation proceeds rapidly. However, most oxytetracycline becomes bound to particulates, and is deposited at the bottom of (or beneath) the fish holding facilities in the case of marine cage sites. Within the sediments, oxytetracycline may remain in concentrations capable of causing antibacterial effects for 12 weeks after the cessation of treatment. Such antibiotic containing sediment affects the fauna. For example, detectable levels of oxytetracycline have been found in blue mussels (*Mytilus edulis*) which were located 80 m from a fish farm using this antibiotic.

The problem with pesticides is not very well understood. Large quantities of a diverse range of natural and synthetic chemicals, including dichlorvos, malachite green, derris root, and tea seed cake, are used in coastal aquaculture worldwide. To illustrate the extent of the problem, it has been determined that during 1989, 3488 kg of dichlorvos was used in Norwegian fish farms to control infestation by salmon lice. Evidence for some compounds such as dichlorvos, has shown that some of these chemicals have adverse environmental effects, and, therefore their use in coastal aquaculture must be carefully assessed. The fate of such compounds should be properly addressed.

Development of antibiotic resistant microbial communities

There's a problem in the development and spread of antibiotic resistance among members of the native aquatic microbial communities. It has been determined that the administration of medicated food has a dramatic effect on the microbial populations within the digestive tract of the aquatic animals.

Plasmids (=extrachromosomal self-replicating elements of DNA), conferring antibiotic resistance properties, abound in fish pathogens and native aquatic bacteria, particularly those in the vicinity of fish holding facilities. Workers have provided evidence of a widespread resistance to antimicrobial compounds. It is conceivable that plasmid-mediated antibiotic resistance could be transferred to bacteria of human veterinary significance. Antibiotic resistance may indeed be transferred between related bacterial group. Fortunately, cessation of treatment appears to lead

to a rapid decline in the levels of antibiotic resistance of microorganisms in the aquatic environment.

Chemicals introduced via construction material

Some construction materials release substances into the aquatic environment (e.g., heavy metals, plastic additives). Their presence is unknown to most of the farmers, although awareness is increasing. Frequently, preservatives have been intentionally used assuming that they are relatively harmless to the cultured species. These include antifoulants, of which the broad ecological effects of tributyltin (TBT) is a good example. Plastics contain a wide variety of additives including stabilizers (fatty acid salts), pigments (chromates, cadmium sulphate), antioxidants (e.g. hindered phenols), UV absorbers (benzophenones), flame retardants (organophosphates), fungicides and disinfectants. Many of these compounds are toxic to aquatic life, although some protection is provided

by their low water solubility, slow rate of leaching and dilution. Mortalities in coastal aquaculture have resulted from toxicant leaching from construction materials, and the environmental effects of these toxicants remain largely unresolved. At present, there are few standards regulating the composition of materials used in aquaculture facilities.

Hormones and growth promoters

An increasing number of hormones and growth promoters are used to alter sex, productive viability and growth of culture organisms. Although many studies have been undertaken to describe their physiological effect in the target organisms, studies of their wider ecological impact have not been undertaken.

Source: GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Pollution), Reducing Environmental Impacts of Coastal Aquaculture. Rep. Stud. GESAMP (47):35p. 1991.



A fisherman brings in a meager harvest of mussels from Dagupan River. Reports about pollution in the area no doubt have an effect on livelihoods like mussel farming.

Source: Phil. Daily Inquirer, Tuesday, January 18, 1995

Use of Chemicals in Intensive Cage Culture

Various therapeutants are used in intensive cage culture to control disease, and other chemicals are used to control external parasites such as sea lice. Concerns over the use of these chemicals relates to their ecotoxicology, the potential for bioaccumulation and in the case of antimicrobial compounds, the development of disease resistance in target and nontarget bacteria.

The problems experienced with the antifouling compound tributyl tin, (used on cage nets) serves as a good example of why full evaluation and strict control is necessary before a compound is allowed to be used in fish farming. Tributyl (now banned for use in aquaculture in most European countries) has also been shown to be toxic to nontarget organism, accumulate in the flesh of the farmed fish and cause mortality of farmed fish, and accumulate through the food chain.

Current concerns center on the use of dichlorvos (Nuvan or Aquaguard), an organophosphorus compound used against parasitic copepods (sea lice). This compound is a general pesticide and therefore is nonspecific, being toxic to a range of crustacean larvae. Extensive use of this compound in intensive cage culture appears to have resulted in the development of resistance in sea lice populations and where repeated treatment of fish has been carried out, increased the sensitivity of fish to the compound. These two factors have reduced the efficacy of the treatment.

Source: RJ Gowen and H Rosenthal. The Environmental Consequences of Intensive Coastal Aquaculture in Developed Countries: What Lessons Can Be Learnt. In: Environment and Aquaculture in Developing Countries. Edited by RSV Pullin et al. 1993.

Socioeconomic effects of intensive cage culture

Although the potential social and economic benefits of aquaculture development are clear, expansion of fish farming has brought this industry into conflict with other users of aquatic resources. This trend of increasing conflict with other forms of coastal development has also been observed in countries which are actively engaged in aquaculture.

Only a few attempts have been made to assess the effects of aquaculture development on tourism and recreation. In

general, however, such studies are subjective and it is difficult to obtain a clear understanding of the effects of aquaculture development. In recognition of some of the problems which have arisen, fish farming associations have produced codes of practice. The Scottish Salmon Growers' Association has produced a voluntary code to avoid visual impact of developments on the landscape. Some organizations, however, suggested that such codes should be integrated into planning procedures and be evaluated.

It is only recently that some countries have attempted to consider coastal zone management as an appropriate tool for ensuring the equitable and sustainable use of coastal marine resources. The Norwegian Government has implemented a scheme referred to as LENKA which includes an evaluation of the ecological, social and economic implications of all poten-

tial activities in the coastal region. The Provincial Government in British Columbia (Canada) has also developed a coastal inventory scheme for minimizing conflict between different activities by identifying potential locations for aquaculture and evaluating existing demands (industrial de-

Proper coastal zone management schemes should allow the equitable and sustainable use of marine resources.

velopment, natural fisheries, tourism and recreation, and nature conservation on the coastal marine environment.

Any coastal zone management scheme should be designed to ensure that there is equitable use of coastal resources and therefore include an environment impact assessment of all potential developments. The localized ecological change brought about by the farm itself, can limit long term production. A detailed assessment of the potential ecological effects of development is desirable. An important feature of such an assessment is that it is proactive, the aim being to anticipate or predict the degree of ecological change and stop or modify the type and scale of production prior to development.

Such an approach requires a full understanding of the interaction between aquaculture and coastal marine ecosystem, an ability to model and hence make

quantitative predictions about the scale of these interactions, and finally the establishment of ecologically acceptable levels of change. With respect to the effects of the waste from intensive cage culture of fish, the interactions are known and models have been developed to predict the scale of these effects. There are few standards for acceptable levels of ecological change. In most European countries, there are strict controls governing the licensing of chemicals for use in aquaculture but in rela-

tion to the interaction between aquaculture and wildlife (including possible genetic interaction).

One of the benefits of appropriate coastal zone management schemes should be that the social, economic and ecological implications of each development are considered parallel. Furthermore, each development must be regarded as part of the total rather than as a discrete development which has no effect on existing or future activities. Proper coastal zone management schemes should allow the equitable and sustainable use of coastal marine resources, based on a broad range of activities.

Source: Gowen, R. and H. Rosenthal. *The Environmental Consequences of Intensive Coastal Aquaculture in Developing Countries: What lessons can be learnt. In: Environment and Aquaculture in Developing Countries* by RSV Pullin et al. 1993.

Adopt sustainable development principle in aquaculture

The full socioeconomic benefits of coastal aquaculture development can only be achieved by adopting the principle of sustainable development, which is defined by FAO as:

“Sustainable development is the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable”

Inadequate planning and inefficient management of coastal aquaculture has resulted into serious socioeconomic consequences. Some examples are:

- Large-scale mangrove conversion for shrimp and fish farming has displaced rural communities which traditionally depended on mangrove resource for their livelihood. In addition to the negative social consequences, the cost of disrupting the ecosystem includes coastal erosion, saltwater intrusion into groundwater and agricultural land, acidification, and a reduction in a range of goods and services produced from the mangrove forests.

- The land subsidence (sinking) in a Taiwan province caused by excessive pumping of groundwater for shrimp and eel culture resulting in significant social costs in terms of salinization of underground water and land due to salt-water intrusion (which reduce agricultural productivity), reduction of freshwater supply (for agricultural, industrial and municipal/domestic uses) and damage to transportation and other infrastructure.

- Financial losses to the Norwegian cage-farming industry due to outbreaks of *Hitra* disease.

- The public health consequences of red tide outbreaks in areas where shellfish are grown.

Some of these problems do not reflect the true cost of resource depletion and environmental change. For example, the true cost related to the

deterioration of coastal water quality are not usually borne by coastal aquaculturists but often spread to other users of coastal waters.

The solution to these problems requires policy intervention at national and local level, particularly to address the issues of common property rights and economic incentives and deterrents needed to minimize ecological change. The use of common resources such as the water and public land for coastal aquaculture development should take into account traditional use and the potential consequences of over-use.

The idea of economic incentives and deterrents such as subsidies and taxes is to encourage aquaculturists to make more efficient use of resources and take full responsibility for mitigating or minimizing ecological changes caused by their culture operation. For example, if aquaculturists had to pay for the scarcity value of water and environmental cost of land subsidence the industry would have developed differently and may have had less environmental impact.

Policy intervention may also include a requirement for regulatory control of the establishment, operation and management of coastal aquaculture. It is clear that to ensure sustainable development, the positive and negative socioeconomic effects of coastal aquaculture, including its ecological effects, must be evaluated in the context of the society's social and economic goals. Analysis of any coastal aquaculture project should take into account both the local and the wider social and ecological costs and balance this against the benefits and costs of the project, which should not be undertaken unless there are net social benefits.

The assessment of wider environmental impacts (socioeconomic and ecological) is needed in an evaluation of the social benefits. The impacts have to be identified, measured and where possible, a monetary value placed on them so that they can be included in a formal analysis. Quantitative evaluation of the impacts of aquaculture on the environment has only recently been seriously attempted, and most of the biophysical relationships involved have yet to be

to page 18

Managing environmental impacts in aquaculture

The growth of the aquaculture industry has become an international phenomenon where the magnitude of the industry reached to a point where substantial environmental impacts have occurred. These impacts resulted in the reduction of production, disease outbreak in cultured and wild populations, and an increase of regulatory restrictions being placed on aquaculture operations. Environmental impacts include issues of recreation and aesthetics, as well as the uses of resources and discharge of nutrients and organic matter into the environment.

Analysis of the potential environmental impact of an aquaculture operation is an essential component of planning to respond to regulatory decisions with regard to the future of the aquaculture venture. Aquaculture operations should be developed and managed with considerations on how the facility's size, technology, and site will affect the environment. Degradation of the environmental quality has been caused by aquaculture operations. In some cases, the result of this concern has been the promulgation of regulations restricting the size of farms, the locations where farms may be developed, the amount of water used in a farm, the concentration of certain substances in the effluent water, and in some cases the total amount of a particular substance that may be released from an aquaculture facility. In other cases, environmental degradation has resulted in substantial reductions in water quality for the aquaculture operations themselves causing disease outbreaks and drops in production.

Resource costs of aquaculture production

Mass balances are convenient tools for examining the possible impact of aquaculture operations on the environment. The culture animals are fed with concentrated feeds as opposed to systems in which fertilizers are used and food production is carried out inside the culture systems. Inputs include feed, water, air or oxygen, and energy. Outputs include fecal and metabolic wastes, uneaten feed or the products of its decomposition, water and fish biomass. Mass balance can be defined in more detail for nutrients or

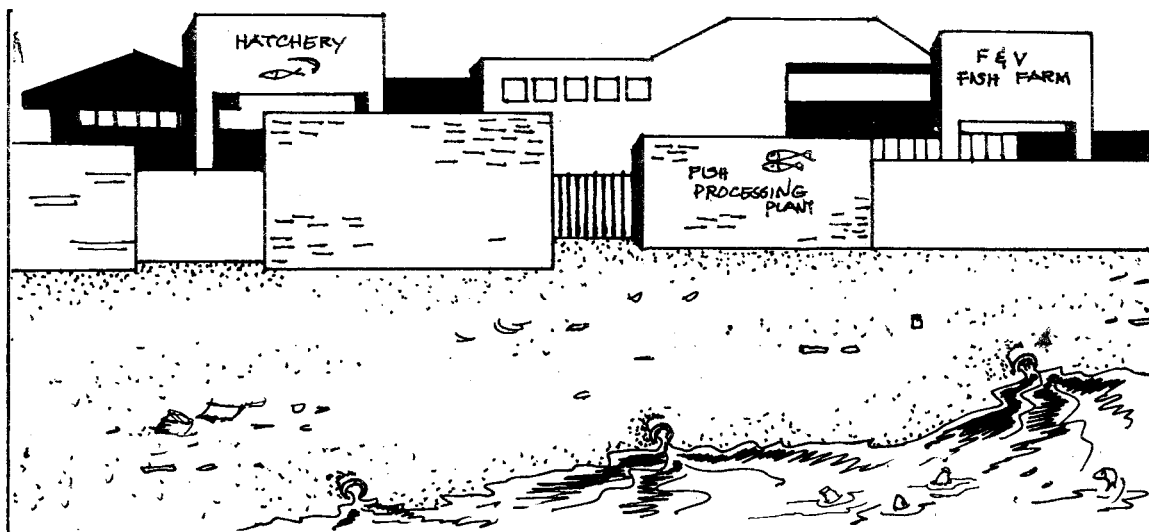
substances (primary nutrients such as nitrogen and phosphorus, dissolved oxygen and organic matter) that are most likely to have significant effects on the environment.

Relationship between aquacultural operations and the environment

Cages. Fish production in 1989 was approximately 98 times the production in 1974. The amount of nitrogen released to the environment during the same time rose by a factor of 58 (from 200 mt to 11,600 mt) and phosphorus a factor of 50 (40 mt to 2,000 mt). The difference between the increase in fish production and rise in nitrogen and phosphorus release is explained by the improvements in feed conversion ratios and feeding practices. It is important to note that improvements were not caused by treatment, containment, or separation of part of the waste stream, but by its input to the system (feed quality and feeding practices). This approach, as opposed to efforts to treat the wastes produced, is understandable given the special characteristics of cage aquaculture and the difficulties that would be associated with containing, conveying and treating waste products from a cage.

Ponds. There are many transformations of nutrients and of organic matter that occur inside a pond, and these depend on how the pond is managed and on-site specific conditions of climate, soil properties, and background water quality. Approximately 17% of the organic carbon, 25% of the nitrogen, and 25% of the phosphorus in the fish are converted to fish flesh. Estimates are based on a feed conversion ratio of 1.6, a feed with 5% nitrogen, 1% phosphorus and 90% dry matter of which 10% is ash. Some of the nitrogen and phosphorus not fixed into fish biomass is lost from the pond as inorganic nutrients. Nitrogen may volatilize as ammonia, or as nitrogen gas if there is active denitrification in the pond, or it may leave the pond with the effluent in the form of ammonia, nitrite, or nitrate. Phosphorus tends to be less mobile and may be

next page



Analysis of the potential environmental impact of an aquaculture operation is an essential component of planning to respond to regulatory decisions with regard to the future of the aquaculture venture.

the pond, or it may leave the pond with the effluent in the form of ammonia, nitrite, or nitrate. Phosphorus tends to be less mobile and may be lost to the pond sediments. Substantial amounts of nitrogen and phosphorus may, however, be lost from the pond in the form of organic matter, some of it actually produced in the pond. The production of 1 mt of catfish results in the production of 3 mt of algal organic matter. The estimate was obtained by difference (i.e., nutrient input in feed minus nutrient fixed as biomass)

Strategies for managing the environmental impact of aquacultural operations

Managing the environmental impact of aquaculture operations is usually limited to reducing the amount of water used and the amount of nutrients released, or of reducing and controlling the negative effects that nutrients released may have on the environment.

Site selection and integration with other activities. Site selection will affect the background concentrations of nutrients, the presence of other environmental "stressors" that may be affecting the overall quality of the ecosystem. Site selection will also affect the "tolerable" levels of nutrient release.

Site selection should be taken into account not only for nutrient releases and overall water quality changes, but also for issues such as the possible transmission of diseases. True quaran-

tines are not technically practical or economically feasible in many aquaculture operations.

Aquaculture has been described as a non-consumptive user of water since water used in aquaculture is released to the environment while still being of very high quality, and approximately the same amount of water that is taken in by the aquaculture operation is released. Aquaculture is a benign water user and that effluents from aquaculture operations can be used in agriculture or other industrial applications. Although this may be true in some cases, it is important to consider the overall flow of various substances through aquaculture systems in order to develop a more comprehensive understanding of how aquaculture might affect the environment.

Input management. A reduction of nutrient inputs has been shown to be an effective strategy for lowering the amount of nitrogen and phosphorus released in the environment. The reduction in nutrient inputs may come in the form of improved feeds: lower feed conversion ratios and more efficient utilization of nutrients in the feed (e.g. nitrogen and phosphorus).

Source: RH Piedrahita. Managing environmental Impacts in Aquaculture. In: Environmental Management in Aquaculture. Bull of Nat. Research Institute of Aquaculture, Supplement No., 1. May 1994.

Go for environment friendly aquaculture

Aquaculture is the farming of aquatic plants and animals (fishes, shrimps, crabs, shells). It may involve seed production (hatchery-nursery) and grow-out production phases. It may be undertaken in land-based or water-based enclosures, either in fresh-, brackish-, or marine waters. In the Philippines, aquaculture has steadily increased its contribution to total fisheries production from only 13.7% in 1978 to 25.3% in 1987. Milkfish and tilapia farming has contributed significantly to the domestic fish supply, and shrimp farming to export earnings.

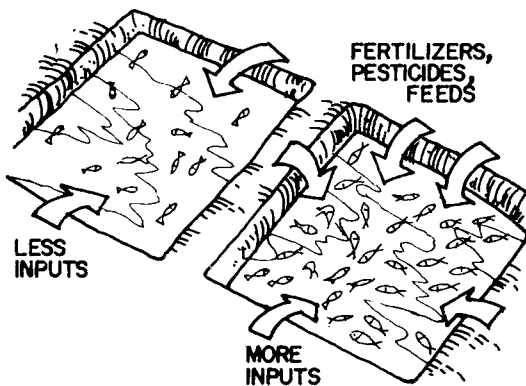
While aquaculture can have considerable economic benefits, it can also have adverse environmental (socioeconomic and ecological) effects:

- Poor farming communities become poorer, with more of the benefits accruing to those already with money.
- Former natural habitats become fragmented.
- Soil, water and landspace qualities deteriorate.
- Animal and plant diversity declines.
- Harmful chemicals and microbes get into common waters.

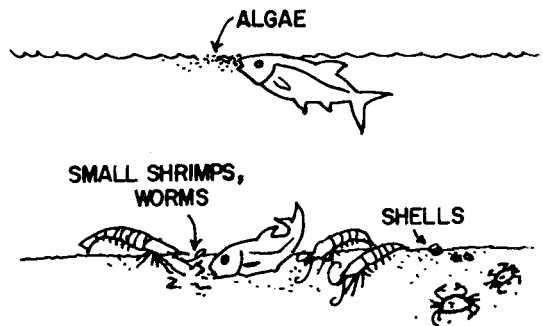
However, this need not be the case if aquaculture facilities are properly designed, operated, managed, and monitored. Aquaculture practitioners and the general public (through advocacy) can take action for environment-friendly aquaculture.

- Go for sustainable, low-input, high-yield culture systems.
- Select native species that feed low on the food chain (plankton-, grass-, or detritus-feeders), grow fast, breed naturally, are disease-resistant and hardy. This eliminates the need for feeds and chemicals such as fertilizers, pesticides, antibiotics and hormones. Exotic species, which may carry diseases and pests or displace local populations, must not be farmed unless they have gone through a stringent quarantine.
- Select proper sites for aquaculture facilities to minimize the environmental impact.
- Conduct a thorough, honest socioeconomic and ecological impact assessment before proceeding with the implementation. Ask who benefits or profits and who loses in

**Semi-intensive farming
(with less feed, fertilizer,
and pesticide inputs)
rather than intensive
farming**



**Polyculture (milkfish with
crab, shrimp, or seabass)
rather than monoculture**



terms of jobs and income; how much land, energy, water, labor, and other resources are diverted from other uses; how the wastes will affect the surrounding community.

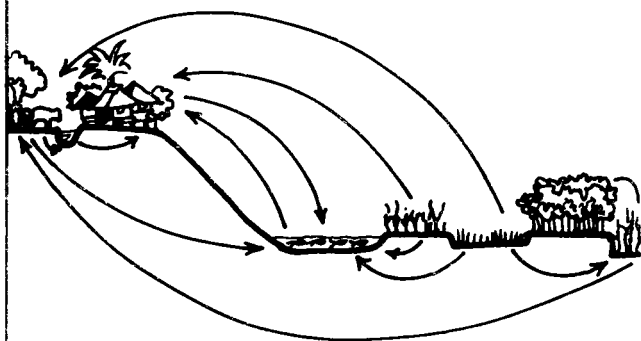
- Practice and promote proper pond/cage/tank preparation and management. Keep buffer strips of mangroves or other trees around the ponds to minimize erosion. Minimize pond tillage that exposes acid soils. If feeds must be used, use the appropriate kind and amount.
- Oppose the clearing of mangrove forests, wetlands, and other virgin areas for new ponds. Replant mangroves or other trees along the dikes of ponds.
- Oppose stream modification and massive ground water extraction for aquaculture. They can cause soil salinization, land subsidence, and flooding.
- Keep freshwater fishponds weed-free and well-stocked to control mosquitoes. Be aware of the water-borne diseases present in the locality and assess whether the establishment and operation of ponds significantly add to

the risks of contraction by farm workers, fish handlers and consumers. Seek professional advice from public health workers.

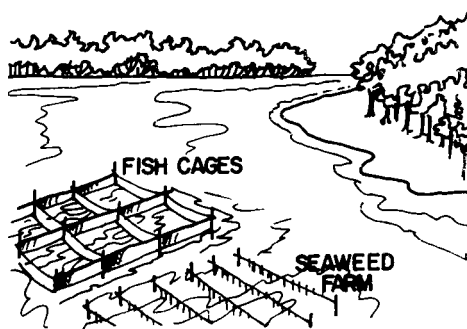
- Support the ban on the production, sale and use of antibiotics, hormones and pesticides in food production.
- Clean (properly treat) waste effluents from aquaculture facilities to prevent adverse effects on other water users. Rimp farms, set aside some filter ponds stocked with filter-feeding mussels and nutrient-consuming seaweeds. Route the pond effluents (with the excess feeds and other wastes) through the filter pond before disposal into coastal waters. Since antibiotics, pesticides and hormones can not be removed from effluents, do not use these chemicals.

Source: T. Bagarinao, I. Tendencia, R. Elizon, M. Castanos and the Environment Action Group. Towards a Viable Environment: What Individuals Can Do. SEAFDEC Aquaculture Dept. Tigbauan, Iloilo. In press.

Integrated agriculture-aquaculture systems (fish-rice, fish-livestock, others)



Seafarming (seaweed farms, oyster and mussel culture, fish cages) in open marine waters rather than in inland waters and mangrove swamps



Recommendations on the effects of aquaculture on public health

Aquaculture must not cause unacceptable risks to public health or harm that negates the benefits of the improved livelihood and nutrition that its adoption can bring. It should be subject to similar controls and safeguards as are applied to agriculture, irrigation and other aspects of food production and handling. This concerns all persons affected by and involved in aquaculture, and to other users of waters in which aquatic organisms are farmed or which are affected by aquaculture: the farm workers, handlers and processors, sellers and consumers of farmed aquatic produce.

The health of aquaculture workers and other users of waters in which aquatic organisms are farmed or which are affected by aquaculture must be safeguarded. There must be effective measures against exposure to waterborne pathogens and parasites, to toxic chemicals used on aquatic farms, and against reduction of water quality for purposes such as domestic supply, watering crops and livestock, washing clothes and utensils, bathing, sports and recreation. Examples of possible health risks to such persons include exposure to

waterborne diseases, such as bilharzia and leptospirosis, and to chemicals such as trace metals, pesticides, disinfectants, antibiotics and hormones; and the risks of working in the aquatic medium, including exposure to harsh climatic conditions and drowning.

All available information on health risks from aquaculture should be compiled as a statistical database with the involvement of appropriate international organizations, such as WHO (World Health Organization) and ILO (International Labor Organization), so as to solve guidelines and codes of practice. This database should be regularly updated as aquaculture expands and experience is increased.

In order to mitigate or avoid public health risks from aquaculture development including consumption of aquatic produce, more research is needed on the real or perceived role of aquaculture operations and their produce in human disease transmission and the risk of chemical and microbial contamination. In particular, population-wide studies are required, especially in developing countries, of exposure to mercury, cadmium, organochlorine pesticides, polychlorinated biphenyls (PCBs) and dioxins. Consumption of aquatic produce may be an important source of exposure. Monitoring

should employ noninvasive techniques (analysis of hair, urine, or breastmilk-as appropriate) in addition to autopsy-derived samples, when available.

Research is also needed on better methods for aquatic disease prophylaxis and control as an alternative to massive use of chemotherapeutics.

Regarding the safety of aquatic produce, monitoring programs for trace contaminants, bioactive compounds and microorganisms are needed. Research and development programs are required to improve the tests available for ensuring the safety of aquatic produce. The present tests for biotoxins, for example, are inadequate to afford an acceptable degree of protection, even when widely employed. Very few of the many trace contaminants which may be present in aquaculture produce are monitored on a regular basis.

Source: RSV Pullin. Discussion and Recommendations on Aquaculture and the Environment in Developing Countries. In: Environment and Aquaculture in Developing Countries. Edited by RSV Pullin et al. 1993.

GUIDELINES FOR THE DEVELOPMENT OF THE ENVIRONMENTALLY ACCEPTABLE COASTAL AQUACULTURE

To ensure that financial gain of any aquaculture activity is not at the expense of the ecosystem or the rest of society, aquaculture development must follow established principle. An outline of this guideline which included general principles and strategies was featured in AFN, Jan-Feb 1994 issue. However, for better understanding, the following plans of action are discussed in detail:

Recommended Actions:

1. Formulate coastal aquaculture development and management plans

A coastal aquaculture development and management plan at national or local level is an essential first step towards achieving the above objectives. Such a plan must be integrated into the overall coastal zone management plans discussed below.

The allocation of potential sites and the selection of forms of coastal aquaculture practice must be preceded by adequate survey and evaluation. Not all the sites found to be technically suitable will be utilized for aquaculture since they will also need to be economically viable and socially and culturally acceptable and their impacts must be within the assimilative capacity of the particular ecosystem. Such planning procedures provide the framework for an orderly development of aquaculture practices including the use of species and culture systems reflecting the physical, chemical and biological characteristics of the site. The scale and level of operation will often depend on societal and economic objectives and investment opportunities. The plans also provide the framework for institutional and legislative arrangements to administer, regulate and monitor the development of aquaculture farms.

2. Formulate integrated coastal zone management plans

Within the general framework of integrated coastal zone management, policy and management guidelines must be established for the allocation of coastal resource to various economic development needs. The zoning approach is one effective means of assigning priorities and limiting development activities to specific areas or zones.

The priority activity in a particular zone acquires "predominant use" status. Other "permitted uses" can be accommodated, but only as long as they do not jeopardize the predominant use. Integrated coastal zone management requires institutional and legislative provisions if it is to succeed in achieving multiple use. This includes zoning regulations and regulatory measures to control effluents. Continued monitoring and evaluation form an important part of integrated coastal zone management programs. Remote sensing and geographical information systems can be effectively used for this purpose, especially to determine changes in resource use over time.

3. Apply the environmental impact assessment (EIA) process to all major aquaculture proposals

EIA is a process whereby the potential impacts of a proposal on the social, biological, chemical and physical environment are assessed and justified, and the means sought to minimize or eliminate negative effects.

4. Select suitable sites for coastal aquaculture

In selecting an appropriate site for aquaculture it is essential to consider, in addition to the socio-economic consideration, the biophysical requirements of the cultured organism, the characteristics of the site and the culture method to be used. In evaluating the characteristics of the site, essential physical, chemical and biological variables should be considered. These include coastline morphology and bathymetry, water temperature and salinity, flushing time, sediment particle size, water movement (current speed and direction), dissolved oxygen, dissolved inorganic nutrient, sedimentary redox-potential and organic content, natural resources and their use, wildlife, planktonic biomass and species composition, and bacterial population.

5. Improve the management of aquaculture operations

Properly sited and managed aquaculture activities should not result in unacceptable ecological change. Nevertheless, should change occur, a number of measures can be used to minimize it.

For example, ensuring good health of the

stock will reduce wastage of feed and the use of bioactive compounds. Techniques, though costly, are also available to collect or disperse waste to reduce the severity of the impact beneath cages. Longer-term measures to reduce waste output from intensive fish and shrimp farms include improvements in the formulation of diets to increase digestibility and the development of techniques to monitor the biomass and health of stock.

6. Assess the capacity of the ecosystem to sustain aquaculture development with minimal ecological change

The concept of environmental capacity can be applied to the control of pollution and assumes that coastal ecosystems have differing quantifiable capacities to assimilate the discharge of a contaminant and provide trophic and non-trophic resources. Thus, in the context of the ecological impact of some coastal aquaculture development in which there can be a net loss or reduction in a variable (as well as the discharge of a contaminant) ecological change can be limited by ensuring that the scale of development does not exceed the availability of a trophic or non-trophic resource or the capacity of the ecosystem to assimilate the changes resulting from production.

7. Establish guidelines governing the use of mangrove wetland for coastal aquaculture

The use of mangroves along the shore front or fringing river banks for aquaculture should be discouraged in view of their significant contribution to coastal stability preventing soil erosion, and their role as valuable habitats. Unlike extensive shrimp farming in mangrove swamps utilizing tidal energy for water exchange and shrimp larvae supply, modern intensive shrimp farming uses mechanical pumps for water supply and seeds from hatcheries. As such there is no justification in the use of mangrove swamps for shrimp culture. Traditional use of mangrove wetland for extensive aquaculture has minimal negative ecological impacts. The use of river basin mangrove should be guided by the recommendations from national mangrove committees which have been established in some nations.

8. Establish guidelines for the use of bioactive compounds in aquaculture

The use of bioactive compounds, including antibiotics and pesticides should be controlled to prevent misuse.

9. Assess and evaluate the true consequences of transfers and introductions of exotic organisms

Transplantation of exotic species beyond their natural range to new habitats for aquaculture and stocking purposes should be carefully and rigidly controlled. Adequate inspection services and quarantine facilities should be made available in both the exporting and importing country before any transfer and importation is authorized. *It should be emphasized that every movement of species to and from aquaculture sites, even within the same general area, should be strictly controlled through inspection and certification.*

10. Regulate discharges from land-based aquaculture through the enforcement of effluent standards

The accumulating effects of discharges on the coastal environment could be greatly reduced by the enforcement of site-and-contaminant-specific effluent standards (e.g. suspended solids, nutrients, and BOD). Levels to be adopted should be within the assimilative capacity of the receiving ecosystems.

11. Establish control measures for aquaculture products

All aquaculture products should conform with safety standards for seafood before they are allowed for human consumption. A directive from the European Community adopts a provisional value of 300 faecal coliforms/100 ml of bivalve tissue. Therefore, it is essential to ensure an adequate sanitary standard for waters in areas supporting aquaculture. Improved water treatment techniques and effluent standards would help to minimize human health risks. Monitoring by the health authority should be established to ensure that the growers comply with such requirements. Depuration and appropriate storage and preservation facilities need to be established to ensure adequate quality products.

12. Increase public awareness of the safety aspects of consuming seafood

Better public awareness of the need for good seawater quality in the production of marine aquaculture products will provide pressure for the control of undesirable inputs to the local environment. A knowledge of the specific risks associated with handling, processing and consuming seafood including aquaculture products could help reduce the incidence of food poisoning and

next page

infections from food-borne organisms. Consumer awareness is an effective way to compel fish farmers to produce hygienic products. The appropriate use of the news media, avoiding the spread of misinformation, can help to increase consumer confidence and to support those seafood industries which are not affected by contamination.

13. Apply incentives and deterrents to reduce environmental degradation from aquaculture activities

Incentives such as concessionary lease of wetlands, tariff exemption on feeds and equipment energy subsidies and depreciation allowances on facilities and deterrents such as taxes on land and water uses and effluent discharge can be used to encourage aquaculturists to make more efficient use of resources and take full responsibility for mitigating or minimizing environmental change.

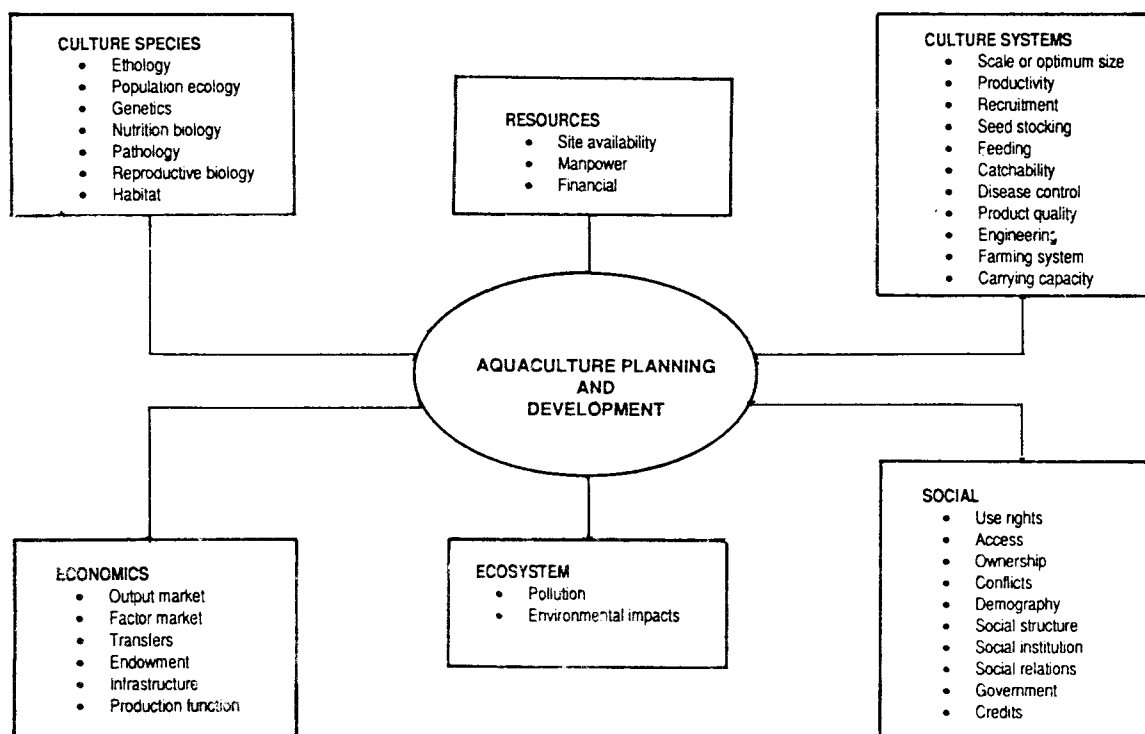
14. Monitor for ecological change

There are existing protocols which have been developed to monitor ecological change in coastal water and in the vicinity of effluent discharge points. However, given that the nature and scale of an ecological impact will depend on the type of

aquaculture practice and the location of the operation it is likely that existing protocols will have to be modified according to local requirements.

The purpose of monitoring for regulatory control of aquaculture development is ecological protection. The aim is to identify the level of, or trend in a particular variable and ensure that it does not fall below or exceed a predetermined value related to the natural conditions for the area. Identification of the spatial and temporal trend in a particular variable will be aided by reducing variation due to seasonality and sampling and method error. Validation of a trend will require statistical analysis and this requires that a sufficient number of samples are collected. Since monitoring is only a means to an end, the results obtained must be used to modify the operation if the change in a variable exceeds or falls below the predetermined.

Source: GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Pollution), Reducing Environmental Impacts of Coastal Aquaculture. Rep. Stud. GESAMP (47):35p. 1991.



Key research areas needed to provide critical information for aquaculture planning and development that are technically sound, socio-economically feasible and environmentally compatible.

Source: Aquaculture in Asia: Quo Vadis? Chua Thia-Eng and Elsie Tech. In: M. Mohan (Ed.) 1990. Aquaculture in Asia, Asian Fisheries Society, Indian Branch, Mangalore, pp 396.

Development of marine farming systems in ICES member countries

Due to economic, social and environmental pressures, there have been changes in farming strategies in the industries. Cage management systems are evolving in ways that may affect the assessment of ACMP (Advisory Committee on Marine Pollution) and the respective Working Groups on research priorities and environmental issues in the future.

These changes include a practice of clustering cage sites separating fish year classes between clusters, and introducing fallow periods between year classes in cage clusters. A separation distance is usually applied between clusters of cages and no longer between individual cage sites.

In Ireland, there is a practice of "fallow and harrow" on shallow sites and, where offshore technologies are involved, there has been a shift to part-time use of offshore technologies such that fish reared in cages are moved offshore in the summer to take advantage of less extreme water temperatures and returned inshore in the winter to avoid the effects of storms.

In Scotland, there is a general tendency toward lower stocking densities of salmon cages; at present, densities are normally not above 15 kg/m³. For similar reasons as in Norway, it is more common for sites not to be confined to single year classes of fish, thus requiring a

larger number of sites. A further consideration of single year class sites is that a site will naturally have a fallow period between the harvesting of one stock and the introduction of the next. This allows some degree of recovery of the impact of sediment on the seabed and also may break the cycle of disease or parasite infection.

A final version of the Technical Report on the Use of Chemicals in Mariculture included topics on veterinary medicine licensing controls, risks to operators, impacts on the environment, drug resistance and a substantial chapter on the relevant chemicals dealing with non-therapeutants such as disinfectants and chemicals associated with the materials used in the construction of mariculture facilities and therapeutic chemicals (anti-microbials).

Management issues and the use of chemicals

The ACMP reported that production trends no longer followed a uniform pattern in ICES (International Council for the Exploration of the Sea) member countries. While salmon production in some countries continued to increase (Scotland, Canada), it remained stable in others (Sweden, Finland, Norway), and declined noticeably in a few countries. These changes had arisen from a combination of disease and husbandry problems, relatively low prices, and production levels possibly exceeding the size of the market.

The use of chemicals does not show a consistent trend and

the quantities of therapeutic and other chemicals used in mariculture could not be determined. Increasing concern is also placed on the fate of antimicrobials in the environment, especially on the development of resistance in bacterial populations. Studies on sediment-water interactions at salmon farm sites have continued in several member countries and progress has been reported in modelling environmental conditions (e.g., nutrient flux, hydrodynamic modelling, etc.) in areas with growing mariculture activities.

Source: ICES Cooperative Research Rep No. 190. Report of the ICES Advisory Committee on Marine Pollution, 1992.

Fishery development and management practices

The changes in the fishery sector in the past two decades call for a reappraisal of the relevance of conventional fishery development and management practices. Many development projects emphasize improved vessels and gears and provide capital for fishers to adopt new technologies. This resulted in increased pressure on marine resources, unemployment and conflict between the large- and small-scale business sectors. The response to stock depletion has been to restrict fishing gear, vessels, or engines that can be used to control fish catch. This can be done if strategies employed are effectively implemented and enforced or access to resources should be limited. There's a need to provide some

next page

The resources available to ensure the continuance of life on earth are finite. Any resource can only serve a limited number of purposes at the same time and place. This is particularly true of water which is a fundamental requirement not only for aquatic but also for terrestrial organisms...

... Aquaculture production is in great demand, but it must not be achieved without due regard to safeguarding our basis of survival..

Dr. Martin Bilio
Senior Adviser for Living
Aquatic Resource Utilization
Federal Republic of Germany

form of exclusive use rights, and adopt more innovative management measures.

Adopting access controls can lead to several problems. One is the general allocation of exclusive userights - essentially a distribution of wealth would generally have to be made at a political level. Another is determining where the management functions are best fulfilled and relating the role of the government with the fishers as a group.

Adopting new management measures thus lead to increased understanding of biological resources in the context of their environment.

More attention is needed on the social and economic factors governing the behavior and strategies of those using the resources.

Research has intensified and developed new culture systems and made a significant contribution to tropical aquaculture. It should, however, expand on the productivity of ponds in inland farming systems and pay more attention to understanding how aquaculture can best be integrated with existing agricultural and forestry practices. Lack of information hindered effective development and management of fisheries although improvements can be made using available information.

Source: *Study of International Fisheries Research: In: Fish for the Future - A Summary Report 1983.*

Adopt sustainable ... from page 8

firmly established. Most research on the environmental impacts of aquaculture has been focussed on intensive production systems for finfish and molluscs but little is known of shrimp culture.

Sustainable aquaculture needs adequate interaction among the social, economic and ecological changes, which accompany development. This can be achieved through an integrated approach to planning and management of coastal aquaculture.

Source: *GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Pollution), Reducing environmental impacts of Coastal Aquaculture. Rep. Stud. GESAMP (47):35p.1991.*

Coastal Aquaculture training course - 8 in a scale of 10

The Coastal Aquaculture training course was rated 8 by its trainees headed by Dr. P. Ravichandran of India. The course which started last January 16 and ended March 10 seemed too short for them who found their stay in SEAFDEC/AQD's main station in Tigbauan much more fun rather than work. Asked about his general impressions of the course, Dr. Ravicharan said "the course practically covered all relevant topics required for coastal aquaculture and has given me enough insights into the aspects". He suggested however that more time can be devoted to practicals and less in theory. "The participants should have a background in biology and brackishwater/mariculture aspect, otherwise it will be difficult for them to understand the course".

The trainees who shared Dr. Ravicharan's impressions found that the Philippines has advanced techniques in coastal aquaculture, especially in shrimp culture.

Coastal areas are economically important throughout the world, especially in Asia and the Pacific. They support a wide diversity of marine life, significant portions of agriculture, industry and tourism.

The increasing variety of pressures placed on coastal resources creates a need for a more rational, equitable and sustainable methods of aquaculture. The training course will reconcile the technological advances and sustainability of coastal aquaculture development.

Other relevant recommendations of the trainees are: the course should be done during the breeding season of the finfishes and prawns so that the trainees could actually rear the larvae themselves and all lecture notes and practical guides must be given before the start of the training course for them to familiarize with the topics.

Workshop on aquaculture sustainability set

The final workshop on aquaculture sustainability and the environment involving 16 countries, being conducted by NACA (Network for Aquaculture Centres in Asia) and the ADB (Asian Development Bank) is scheduled on 3-9 October 1995 in Beijing. The workshop will (1) review the results of the farm-level survey which focused on shrimp and carp farming systems and (2) evolve a regional action plan for research, human resource development and information exchange. A database system has been established to analyze the farm records of 7,000 carp farms and 6,000 shrimp farms. This will be the basis for the continuing development and dissemination of information on the performance of farming systems. The ADB/NACA study is designed to establish the key factors that determine the sustainability of aquaculture farms.

To be presented and discussed are the results of the country studies, a regional overview analysis of the Project Team, and specialist reviews in the areas of farming systems, environment, water quality, fish health management and nutrition, policy development, investment opportunities, and opportunities for co-operation in research, information development and exchange.

Country participants will include officials involved in policy development and implementation, the National Farm Performance Coordinator, and representatives of the private sector. Regional and international resource persons will present the specialist technical reviews.

Contact

NACA, P.O.Box 1040
Kasetsart Post Office
Bangkok 10903 THAILAND

Tel: (66-2)561-1728 to 29

Fax: (66-2)561-1727

Telex: 84267 NACA TH

E-mail: bancht@morakot.necnec.orth

IN THIS ISSUE

Vol. XIII, No. 2, March-April 1995

- Aquaculture wastes, p. 1
- Ecological impacts of coastal aquaculture, p. 2
- Use of chemicals in intensive cage culture, p. 6
- Socioeconomic effects of intensive cage culture, p. 7
- Adopt sustainable development principles in aquaculture, p. 8
- Managing environmental impacts in aquaculture, p. 9
- Go for environment friendly aquaculture, p. 11
- Recommendations on the effects of aquaculture on public health, p. 13
- Guidelines for the development of environmentally acceptable aquaculture, p. 14
- Global Trend, p. 17
- AQD News, p. 19

AFN is a production guide for fishfarmers and extension workers. It discusses the technology for cultured species and other recent information excerpted from various sources.

In citing information from AFN, please cite the institutional source which is not necessarily SEAFDEC/AQD. Mention of trade names in this publication is not an endorsement.

Editor this issue: E. Aldon; Production: D. Badilles, R. Buendia, E. Ledesma, L. Plondaya, J. Requintina, I. Tendencia; Circulation: R. Tenedero, L. Tabigo-on, Jr.

Subscription rate: P40 per year (local), US\$ 15 per year including air mail postage (foreign). Please make remittances in postal money order, bank draft, or demand draft payable to SEAFDEC/AQD.

Entered as second class mail at the PPC Tigbauan, Iloilo.

Aqua Farm News is published bimonthly by the Aquaculture Department of the Southeast Asian Fisheries Development Center P.O. Box 256 Iloilo City 5000 Philippines

Antibiotics - to be or not to be?



by E. LEDESMA



Better life through aquaculture